Marked-Up Copy of the Substitute Specification

NOTES:

1. Added materials are in *italics*.

2. Deleted materials are in ~~strikethrough~~.

3. Materials from the original specification are in normal fonts.

4. All figures are moved to the drawings section, enclosed separately. Deleted figures are marked **[FIGURE DROPPED]** in their caption.

This application is submitted in the name of the following inventor(s).

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TITLE OF THE INVENTION

High-Speed Low-Power CAM-Based Search Engine

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates generally to search engines for routers.

Related Art

The Internet was created for the purpose of sharing information between research universities and government agencies. However, with greater commercial and individual use, Internet traffic has grown exponentially, leading to increased problems associated with routing messages. Messages are routed (or switched) by routing or

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1   switching devices, herein called "routers." Routers serve as the principal devices by

2   which messages are received and forwarded using communication paths. Routers pref-

3   erably select substantially optimal paths for messages in response to factors related to the

4   condition of the paths and the status of the network.

5

6   One known problem is that router speed is often not sufficient to keep up

7   with message traffic. Messages are sent using packets, relatively smaller blocks of data

8   that are received by a router (or switch) and forwarded on to their destination(s). Packets

9   include at least two parts, (1) a header with the address of the source and destination

10 computers, and (2) data to be sent with the packet. For example, upon sending an e-mail

11 message to a recipient, the message can be broken into multiple packets for travel on dif-

12 ferent communication paths within the Internet to the ultimate destination.

13

14 In preferred embodiments, routers use known protocols including TCP

15 (transmission control protocol) and IP (internet protocol). As known in the art of routing

16 messages, TCP breaks messages into data packets and reassemble them in order once they

17 reach their ultimate destination. As known in the art of routing messages, IP assigns each

18 packet a unique source IP address (and at least one IP destination address). Each router

19 reads the destination IP addresses and determines which path is the best one for the

20 packet to take its ultimate destination. In preferred embodiments, the router makes this

21 determination in response to a routing table of routing treatments for each destination IP

22 address.

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2   The routing table includes a set of routing treatments associated with each

3   destination IP address (and possibly also responsive to the source IP address in the case of

4   multicast packets). The routing table can be constructed by the router in response to in-

5   formation about the network gleaned by the router, received by the router from other

6   routers, and in response to other factors.

7

8   In the presence of relatively heavy network traffic, the router can become

9   overloaded; that is, packets arrive at the router faster than the router can process them. In

10   such cases, excess packets are queued for their particular input interface at the router, and

11   remain queued until processed. If the queue overflows, the router can be forced to refuse

12   to process one or more packets, causing those packets to not reach their destinations.

13   Although other message sending protocols generally have retry techniques for response to

14   this problem, message retry can be substantially time consuming and result in perform-

15   ance degradation at the router.

16

17   One known technique to improving router speed includes using a CAM

18   (content addressable memory) to speed operation of the router in accessing its routing ta-

19   ble. Although this technique has the advantage of improving router speed, it is subject to

20   several drawbacks. First, CAM devices have relatively high power requirements, thus

21   requiring expensive packaging. Second, CAM devices have relatively limited amounts of

22   memory that can be stored on a single chip. Third, CAM devices are relatively difficult to

1   coordinate among multiple chips, with the result that CAM size can become a limiting

2   factor for router operation.

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4   Accordingly it would be advantageous to provide a technique for CAM

5   lookup in a router that is not subject to drawbacks of the known art.

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7   SUMMARY OF THE INVENTION

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9   The invention provides a method and system for integrating a CAM (con-

10 tent addressable memory) based ASIC (application-specific integrated circuit) to allow

11 lookups to keep up with message speeds over optical fibers.

12

13   In a preferred embodiment, the routing table includes at least one, and pos-

14 sibly many, chips with CAM memory banks. Each chip contains entries from a selected

15 range of the address space, and within each chip those entries are further divided into

16 several banks. Preferably, each bank contains entries of identical prefix length. De-

17 pending on the number of entries for each prefix length on each chip, several banks may

18 be required to store entries for a single prefix length. Within those several banks, each

19 one includes entries from a selected address range. Thus, each address lookup need only

20 activate one bank per prefix length in order to obtain a lookup match.

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4

1 ~~A Content Comparable Memory (CCM) is contained within each CAM~~

2 ~~bank; this CCM stores and compares the least possible address that will match the entries~~

3 ~~in the table with the incoming address. If the incoming address is found to be greater or~~

4 ~~equal to the data stored in the CCM but less than the data in the next bank's CCM which~~

5 ~~contains addresses of the same prefix length, the incoming address will be directed to the~~

6 ~~rest of the CAM bank for comparison.~~

7

8 ## ~~DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT~~

9

10 In this application, a preferred embodiment of the invention is described

11 with regard to process steps and data structures. Those skilled in the art would recognize,

12 after perusal of this application, that embodiments of the invention can be implemented

13 using circuitry or other structures adapted to particular process steps and data structures,

14 and that implementation of the process steps and data structures described herein would

15 not require undue experimentation or further invention.

16

17 ## ~~TECHNICAL APPENDIX~~

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19 ~~The enclosed technical appendix includes further information and detail re-~~

20 ~~garding the invention and a preferred embodiment thereof. The enclosed technical ap-~~

21 ~~pendix is an integral part of this application, and is hereby incorporated by reference as if~~

22 ~~it were fully set forth herein.~~

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2 *Alternative Embodiments*

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4   Although preferred embodiments are disclosed herein, many variations are

5 possible which remain in the concept, scope and spirit of the invention, and these varia-

6 tions would be clear to those skilled in the art after perusal of this application.

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ABSTRACT OF THE DISCLOSURE

The invention provides a method and system for integrating a CAM-based ASIC that will allow lookups to keep up with transmission speeds over optical fibers. The lookup table includes chips with CAM banks. Each chip contains entries from only a certain range of the address space, within each chip the entries are divided into several banks. Each bank contains entries of the same prefix length. Depending on the number of entries in each prefix length on each chip several banks may be required to store these entries. Each bank contains entries contained in a particular address range. Each address lookup will activate one bank per prefix length in order to get a match. A Content Comparable Memory (CCM) is contained within each CAM bank; this CCM stores and compares the least possible address that will match the entries in the table with the incoming address. If the incoming address is found to be greater or equal to the data stored in the CCM but less than the data in the next bank's CCM which contains addresses of the same prefix length, the incoming address will be directed to the rest of the CAM bank for comparison.

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